obtenue dans la position horizontale était identique à celle obtenue au moyen des collimateurs par les procédés physiques ordinaires.

En dehors des flexions que M. Marth croit à tort pouvoir évaluer avec son appareil, mon instrument permet encore de déterminer la flexion de l'axe central et la forme des tourillons. On comprendra maintenant toute la différence qui existe entre les deux appareils : avec le mien, on mesure avec la plus haute précision et de plusieurs manières, non-seulement la flexion de l'objectif et la flexion de l'oculaire, mais aussi la flexion absolue de l'axe instrumentale et la forme des tourillons, ainsi que tous les mouvements de l'appareil.

Avec l'autre, au contraire, en admettant, ce qui en réalité est impossible, que l'on puisse évaluer les mouvements de l'appareil, on n'obtiendrait que les deux premières données du problème ; c'est-à-dire la flexion de l'objectif, et la flexion de l'oculaire.

On some Results obtained from the Meridian Observations of Mars at the Opposition of 1877. By E. J. Stone, M.A., F.R.S.

A very large number of meridian observations of *Mars* and comparison stars near the planet were made during the Opposition of 1877, at the principal Southern Observatories. The co-operation of the Northern Observatories was not so general as could have been wished ; but a valuable series of corresponding observations were secured at Leyden and Washington.

The results of the observations were forwarded, by arrangement, to the Washington Observatory for discussion. A value of the solar parallax has been recently deduced from a discussion of these observations by Professor Eastman, an assistant at the Washington Observatory, and the results have been published as Appendix III, "Washington Observations," 1877. The value of the solar parallax thus found is

$$8''.953 \pm 0''.019.$$

This value has been deduced solely from a comparison of the North Polar Distances of *Mars*, which were made within a few hours of each other. The method has therefore the advantage of practically avoiding the necessity for any correction of errors of tables ; but this advantage is dearly purchased by the loss of a large number of valuable observations, unless a very considerable number of corresponding observations should be found available. The separate results obtained by Professor Eastman were—

From Washington and Melbourne	8″·9712 ±	0″·0316
Washington and Cape	8·8960	0·0725
Washington and Sydney	8·8846	0·0546
Leyden and Melbourne	8·9693	0·0260.

These separate results are accordant within their probable errors.

For some reasons, which are unassigned, no direct comparisons appear to have been made between the Leyden, the Cape, and Sydney Observations.

In addition to the Leyden and Washington observations, some observations of the Transits of *Mars* and the comparison stars were made over oblique systems of wires at Cambridge, United States; but it is very doubtful whether these observations, made by a method essentially different from that adopted at the other stations, can be properly combined with the other observations. These Cambridge observations, combined with the Melbourne observations, have given Professor Eastman a value of the solar parallax of

$$9''\cdot1382 \pm 0''\cdot0496.$$

The results which would be obtained by a combination of these Cambridge observations with the corresponding observations made at the Cape and Sydney would not differ greatly from this value; but, for the reason given, it is hardly necessary to complete this part of the investigation.

There has unfortunately been a considerable delay in bringing forward the results obtained from these *Mars* observations; but I did not feel myself justified in discussing these observations before the publication of Professor Eastman's paper, and I should have been exceedingly glad if I could have regarded Professor Eastman's discussion as exhaustive. But of the thirty-eight observations of *Mars* which were made in 1877 at the Cape only nine are included in the discussion, and two of the results are rejected on account of supposed defects in the Cape observations; whilst of forty-four Sydney observations of *Mars* only eleven have been included in the discussion, and the results have in four cases been rejected as defective.

The rejection of the Cape observations of September 1 and September 3 is certainly, in my opinion, quite uncalled for; and I consider that the value of these observations cannot properly be estimated without a consideration of the residual errors of *all* the observations of *Mars* made at the different stations, and the consideration of what changes in these residuals would be introduced by any considerable alteration of the adopted value of the solar parallax. This work I have done, so far as the materials are at present available to me, and I hope to complete the work.

But I have met with a difficulty which renders me unable, at

present, to include the Sydney observations in the discussion. In the original scheme of observations it was recommended that the plan adopted by Dr. Winnecke in 1862 should be followed :—

"Two threads of equal size are inserted in the moveable declination system of the field of the telescope, the distance between them being 3″ or 4″ less than the minimum diameter of the planet during the proposed period of observation. The observation is effected by moving these threads until the two small segments of the planet outside of the threads are seen to be exactly equal. If the thread nearest the micrometer head is designated as thread *a* and the other as thread *b*, then the comparison stars should be observed by bisecting the first, fourth, fifth, and eighth stars with thread *a*, and the second, third, sixth, and seventh stars with thread *b*. This order should be reversed on alternate nights, but in all cases the thread used in bisecting ought to be carefully recorded for each star."

Now, on page 15 of Professor Eastman's paper it is stated as follows :—

"SYDNEY.

"The observations at Sydney were made with Simm's Transit Circle by Government Astronomer H. C. Russell and Assistant H. A. Lenehan, and according to the method proposed in the circular. They also made a separate observation of *Mars* by bisecting 'with the wire used for the Nadir observation, at the reading zero, *before* the planet came on to the Transit wires.' These extra observations differed so widely from the others that they have not been used."

The Sydney observations of *Mars* and stars are given on pages 31 to 36 of the Sydney Observations, 1877–78. The only information respecting these observations which is available to me at present is on page 6 of the Introduction, where it is stated :—

"The declination micrometer has only one wire, and is fitted with a head counter similar to that on the collimation micrometer. For the purpose of observing *Mars* a second wire was put in 19″·68 from the zero wire, but as it was found to be somewhat in the way when taking the Nadir readings it was removed."

Now, the following is a specimen of a day's work as given in the Sydney volume 1877–1878.

1877, *September* 2.

Name.	R.A.	N.P.D
70 Aquarii	22 42 5·69	101 11 55·56
74 Aquarii	—	102 15 51·66
B.A.C. 8004	—	103 43 24·65
Mars	—	101 56 1·60 *α*
Mars	22 12 21·37	101 56 13·49 *β*
B.A.C. 8199	23 25 53·62	102 12 57·59
B.A.C. 8266	23 40 59·33	102 35 2·97

No intimation is here given of the stars which are bisected by the wires a, b, respectively. And unless great care is taken to balance the observations of stars made with each wire there is always a suspicion of the possibility of systematic error in this method. It is not stated whether the observations of *Mars* are or are not corrected for defective illumination. And there appears to me a considerable difficulty in determining which of the two observations of *Mars* (α) or (β) is really that made by the method of equal segments. Professor Eastman has taken the observation (α) with N.P.D.$=101^\circ\ 56'\ 1''{\cdot}60$ as that made by the method of equal segments, and β with N.P.D.$=101^\circ\ 56'\ 13''{\cdot}49$ as that made by simple bisection; and the observations β have been rejected from the discordance of the results.

I presume that Professor Eastman has had direct information on the point from Mr. Russell, and that the course which he has followed is correct. But I must confess that I should hardly have come to this conclusion from the mere observations, as recorded in the Sydney volume 1877–1878.

It would almost appear from these observations, as recorded, that the stars have been observed on, or reduced to, the principal wire, and that (α) represents the attempt to fix the centre of *Mars* by "bisecting with the wire in ordinary use, before the planet came to the transit wires." In this case the reading β, or $101^\circ\ 56'\ 13''{\cdot}49$, would represent the principal observations of *Mars* made by the method of equal segments; but, supposing it recorded as observed, it would require a correction of $9''{\cdot}84$, which corresponds to half the distance between the parallel wires a and b. This would make the two results α and β agree fairly with each other. On the other hand, if Professor Eastman is right in his selection of the principal observations—and I presume that such must be the case—then, undoubtedly, there is something wrong in the observations as recorded, and some confusion in reducing the observations to a common wire, for it is quite impossible that a constant error of about $10''$ can have been made in bisecting such a planet as *Mars* even by a direct attempt to find the centre.

I have worked up these Sydney observations; but it appeared to me not desirable to give them until the points mentioned have been cleared up.

The results contained in the Table have been obtained as follows:—

I have first computed star-corrections for all the observations of the comparison stars selected for observation with *Mars*. With these star-corrections, mean North Polar Distances have been formed. The mean of the separate results for each star for the Cape, Leyden, Melbourne, and Washington, have then been separately found, and the mean of these four separate results adopted as the North Polar Distance of the star for the purposes of this discussion.

In the determination of a value of the solar parallax from a discussion of observations like those under consideration, the tabular places of the stars are entirely eliminated when the same stars are observed at all the stations. The course now adopted allows of the exhibition of the results on days when some of the comparison stars are wanting, without the introduction of any important systematic errors; and, if desired, the errors can be exhibited as corrections to the final result. The mean of the differences between the mean North Polar Distances of the comparison stars and the adopted mean North Polar Distances is then found for each day at each station, and these mean differences are considered as index corrections applicable to the North Polar Distance of *Mars* on the same day for the station. The tabular North Polar Distances have been, for the present purpose, directly interpolated from the *Nautical Almanac*, and the value $8''{\cdot}95$ has been adopted as the value of the horizontal equatoreal solar parallax.

The "error of the tables" is the excess of the observed North Polar Distance over the tabular North Polar Distance.

These errors have been laid down as ordinates, of which the corresponding times are the abscissæ; and a curve has been swept amongst the points laid down. The corrections for "errors of tables" are the corrections read off from this curve. The residual errors are the excesses of the tabular errors over those read off from the curve.

The residual errors, therefore, represent the real errors on the assumption of the accuracy of the mean curve of errors. It will be seen that the residual errors are small for all the stations. And there appears no strongly-marked preponderance of positive or negative signs between the results for the Northern and Southern Observatories over any considerable portion of the curve. This is the only important point so far as a determination of the Solar Parallax is concerned.

The mean residual errors are very small indeed for all the stations.

Day.	Cape. Errors of Tables.	Cape. Corr. for Errors of Tables.	Cape. Residual Errors.	Melbourne. Errors of Tables.	Melbourne. Corr. for Errors of Tables.	Melbourne. Residual Errors.	Leyden. Errors of Tables.	Leyden. Corr. for Errors of Tables.	Leyden. Residual Errors.	Washington. Errors of Tables.	Washington. Corr. for Errors of Tables.	Washington. Residual Errors.	Day.
	″	″	″	″	″	″	″	″	″	″	″		
July 20							2·74	2·52	+0·22				July 20
21				2·65	2·54	+0·11	2·10	2·56	−0·46				21
22				3·26	2·60	+0·66							22
23				2·69	2·66	+0·03	2·45	2·69	−0·24				23
24													24
25													25
26													26
27				2·78	2·87	−0·09							27
28				3·66	2·93	+0·73							28
29				2·69	2·96	−0·27				3·52	3·03	+0·49	29
30				3·30	3·03	+0·27	2·81	3·04	−0·23	3·50	3·06	+0·44	30
31													31
Aug. 1	3·00	3·13	−0·13										Aug. 1
2	3·46	3·16	+0·30										2
3	2·21	3·20	−0·99	2·83	3·17	−0·34							3
4													4
5				3·56	3·26	+0·30							5
6							3·73	3·33	+0·40	3·26	3·35	−0·09	6
7	3·75	3·35	+0·40	2·97	33·3	−0·36							7

Day	*Cape.* Errors of Tables.	Corr. for Errors of Tables.	Residual Errors.	*Melbourne.* Errors of Tables.	Corr. for Errors of Tables.	Residual Errors.	*Leyden.* Errors of Tables.	Corr. for Errors of Tables.	Residual Errors.	*Washington.* Errors of Tables.	Corr. for Errors of Tables.	Residual Errors.	Day.
	"	"	"	"	"	"	"	"	"	"	"	"	
Aug. 8				2·92	3·37	−0·45	2·92	3·39	−0·47				Aug. 8
9	3·76	3·43	+0·33	4·27	3·42	+0·85							9
10				3·10	3·44	−0·34							10
11				2·89	3·47	−0·58							11
12				3·07	3·52	−0·45							12
13	2·96	3·56	−0·60	4·35	3·55	+0·80							13
14	4·02	3·58	+0·44	3·50	3·57	−0·07							14
15	3·87	3·62	+0·25	4·26	3·60	+0·66	3·39	3·62	−0·23				15
16				4·31	3·63	+0·68							16
17				3·60	3·65	−0·05	3·89	3·66	+0·23				17
18	3·32	3·68	−0·36							3·61	3·70	−0·09	18
19													19
20	3·24	3·73	−0·49										20
21				2·63	3·73	−1·10	3·74	3·74	0·00	1·20	3·75	−2·55	21
22							3·63	3·76	−0·13				22
23				3·84	3·76	+0·08							23
24				3·49	3·77	−0·28							24
25				4·54	3·79	+0·75							25
26				4·68	3·80	+0·88							26

Day.	*Cape.* Errors of Tables.	Corr. for Errors of Tables.	Residual Errors.	*Melbourne.* Errors of Tables.	Corr. for Errors of Tables.	Residual Errors.	*Leyden.* Errors of Tables.	Corr. for Errors of Tables.	Residual Errors.	*Washington.* Errors of Tables.	Corr. for Errors of Tables.	Residual Errors.	Day.
	″	″	″	″	″	″	″		″	″	″	″	
Aug. 27				3·93	3·80	+0·13				3·49	3·80	−0·31	Aug. 27
28				2·72	3·80	−1·08				3·73	3·79	−0·06	28
29	2·86	3·78	−0·92	3·21	3·79	−0·58							29
30	3·67	3·77	−0·10	4·10	3·78	+0·32	3·78	3·77	+0·01				30
31	3·44	3·76	−0·32										31
Sept. 1	2·96	3·74	−0·78	3·47	3·75	−0·28	4·13	3·74	+0·39	5·41	3·73	+1·68	Sept. 1
2				4·33	3·73	+0·60	3·51	3·72	−0·21				2
3	3·87	3·72	+0·15							5·49	3·71	+1·78	3
4	3·95	3·70	+0·25	3·80	3·71	+0·09	3·32	3·70	−0·38				4
5				2·60	3·69	−1·09							5
6	3·83	3·66	+0·17	2·60	3·68	−1·08							6
7				4·10	3·66	+0·44							7
8													8
9													9
10	2·85	3·57	−0·72										10
11	3·35	3·54	−0·19										11
12	4·07	3·52	+0·55										12
13	3·46	3·49	−0·03	4·14	3·50	+0·64							13
14				1·80	3·46	−1·66							14

Day.	*Cape.* Errors of Tables.	*Cape.* Corr. for Errors of Tables.	*Cape.* Residual Errors.	*Melbourne.* Errors of Tables.	*Melbourne.* Corr. for Errors of Tables.	*Melbourne.* Residual Errors.	*Leyden.* Errors of Tables.	*Leyden.* Corr. for Errors of Tables.	*Leyden.* Residual Errors.	*Washington.* Errors of Tables.	*Washington.* Corr. for Errors of Tables.	*Washington.* Residual Errors.	Day.
	″	″	″	″	″	″	″	″	″	″	″	″	
Sept. 15	4·12	3·40	+0·72	3·48	3·43	+0·05				3·23	3·37	−0·14	Sept. 15
16				3·62	3·38	+0·24							16
17	3·50	3·33	+0·17	2·93	3·34	−0·41	2·59	3·33	−0·74				17
18	3·76	3·29	+0·47	3·57	3·31	+0·26							18
19	2·60	3·24	−0·64										19
20	3·46	3·20	+0·26										20
21							3·09	3·15	−0·06	2·74	3·13	−0·39	21
22				2·77	3·13	−0·36							22
23													23
24	2·53	3·03	−0·50	3·09	3·05	+0·04				2·82	2·99	−0·17	24
25	3·05	2·95	+0·10	3·30	2·97	+0·33	2·60	2·95	−0·35				25
26	3·04	2·89	+0·15	2·76	2·92	−0·16				3·15	2·86	+0·29	26
27	2·51	2·83	−0·32	2·47	2·86	−0·39	2·56	2·83	−0 27				27
28	2·32	2·76	−0·44	2·04	2·79	−0·75							28
29	2·86	2·70	+0·16										29
30													30
Oct. 1	2·06	2·56	−0·50	1·73	2·58	−0·85	2·29	2·56	−0·27	2·96	2 54	+0·42	Oct. 1
2	2·07	2·50	−0·43	2·92	2·52	+0·40	2·09	2·50	−0·41	2·14	2·47	−0·33	2
3	2·61	2·44	+0·17	2·39	2·46	−0·07	2·25	2·44	−0·19				3

Day.	*Cape.* Errors of Tables.	Corr. for Errors of Tables.	Residual Errors.	*Melbourne.* Errors of Tables.	Corr. for Errors of Tables.	Residual Errors.	*Leyden.* Errors of Tables.	Corr. for Errors of Tables.	Residual Errors.	*Washington.* Errors of Tables.	Corr. for Errors of Tables.	Residual Errors.	Day.
	″	″	″	′	′	″	″	″	″	″	″	″	
Oct. 4	1·14	2·38	−1·24	2·12	2·40	−0·28	2·01	2·38	−0·37				Oct. 4
5	1·52	2·32	−0·80	2·27	2·34	−0·07							5
6	3·20	2·22	+0·98	2·94	2·24	+0·70	2·20	2·22	−0·02	1·62	2·20	−0·58	6
7				1·58	2·18	−0·60							7
8				3·02	2·13	+0·89							
9				2·31	2·06	+0·25	3·03	2·03	+1·00	2·23	2·01	+0·22	9
10				1·78	2·00	−0·22							10
11				2·72	1·94	+0·78							11
12				1·21	1·87	−0·66				1·52	1·83	−0·31	12
13													13
14				2·10	1·76	+0·34	2·63	1·73	+0·90	1·58	1·71	−0·13	14
15				1·71	1·71	0·00	2·14	1·67	+0·47	1·77	1·65	+0·12	15
16				2·51	1·63	+0·88							16
17										2·34	1·55	+0·79	17
18				1·32	1·54	−0·22				1·82	1·50	+0·32	18
19													19
20													20
21				1·28	1·43	−0·15	1·94	1·41	+0·53				21
Oct. 22				1·76	1·33	+0·43							Oct. 22

The results given by this Table appear to me important. The Cape observations began on August 1, and were continued to October 6, and embrace the period when the horizontal equatoreal parallax of *Mars* was 20″.

If we take the corresponding residuals for all four stations during the period August 1 to October 6, we obtain the following results :—

	Southern Stations.		*Northern Stations.*	
Mean Results.	Cape 38 obs.	Melb. 46 obs.	Leyden 19 obs.	Wash. 14 obs.
Residual Error ...	−0″·118	−0″·085	−0″·162	−0″·039
Error of Tables ...	+3·112	+3·261	+3·038	+3·203
Correction applied .	−3·230	−3·346	−3·199	−3·242
Factor of Parallax .	+0·90	+1·07	−2·19	−1·89

If we include the observations during the whole period July 20 to October 22, we obtain the following results :—

	Southern Station.	*Northern Stations.*	
Mean Results.	Melb. 65 obs.	Leyden 27 obs.	Wash. 22 obs.
Residual Error	−0″·011	−0″·033	+0″·064
Error of Tables	+2·990	+2·873	+2·870
Correction applied ...	−3·001	−2·905	−2·806

In both cases these observations admit of no important alteration of the adopted value of the solar parallax, 8″·95 ; and the agreement between the results affords no grounds for suspicion of a difference of personality in the contacts with the upper and lower limbs of *Mars*.

As the observations of *Mars* at the Cape and Melbourne were made by the method of tangents to the limbs, whilst those at Leyden and Washington were made by the method of equal segments, it may be desirable to point out that the results obtained by both methods lead, as might be expected, to sensibly identical results. In 1862, the Pulkova and Cape observations were made by the method of equal segments ; but the Greenwich and Melbourne observations were made by the method of tangents. The Pulkova and Cape observations gave 8″·96 for the value of the solar parallax, whilst Greenwich and Cape gave 8″·92, and Greenwich and Melbourne gave 8″·94.

Unless it can be proved that there is some cause which affects differently the observations of *Mars* at the Northern and Southern stations, these observations and the corresponding results obtained in 1862 would appear to render it impossible that any value of the solar parallax as small as 8″·75 can be